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Service Manual

Open Circuit Axial Piston Pumps
Series 45 E Frame

Revision history

Table of revisions

Date	Changed	Rev
August 2015	Danfoss Layout	0300
October 2012	add new control types	AG
November 2010	new last page	AE
February 2010	fix Osaka address	AD
March 2008	add displacement limiter specs	AC
March 2005	First edition	A

Contents

Introduction

Overview....5
Safety precautions....5
Unintended machine movement....5
Flammable cleaning solvents....5
Fluid under pressure....5
Personal safety....5
Symbols used in Danfoss literature....6
General description....7
System circuit....8

Technical specifications

General specifications....9
Type of mounting....9
Auxiliary mounting pad options....9
Control options....9
Port options....9
Direction of rotation....9
Installation position....9
Technical specifications....9
Hydraulic parameters....11
Inlet pressure....11
Pressure compensator valve setting....11
Case pressure....11
Hydraulic fluid....11
Temperature range [1]....11
Fluid viscosity....11
Filtration....11

Features

Displacement limiter....12
Auxiliary mounting pads....12
Input shafts....13
Control options....13
General....13
PC control....13
LS control....14
Electric Proportional Controls....15
Electric On/Off Controls....15
Electronic Torque Limiting Controls (ETL)....16
PLUS+1® Compliance....16

Pressure measurement

Required tools....18
Port locations and gauge installation....18

Initial Start-Up Procedures

General....19
Start-up procedure....19

Fluid and Filter Maintenance

Recommendations....20

Troubleshooting

Excessive noise and/or vibration....21
Actuator response is sluggish....21
System operating hot....21
Low pump output flow....22
Pressure or flow instability....22
System pressure not reaching PC setting....23
High inlet vacuum....23

Contents

Adjustments

PC control....24
LS control....26

Minor repair

Shaft seal replacement....28
- Removal....28
- Installation....28

Auxiliary pads....29
- Removal....29
- Installation....29

LS and PC Controls....30
- Disassembly....30
- Inspection....31
- Reassembly....31

Electric Controls....33
- Disassembly....33
- Inspection....33
- Reassembly....34

Electronic Torque Limiting Control....35
- Repair....35

Angle Sensor....36
- Removal....36
- Inspection....36
- Reassembly....37

Servo Control Orifice....38
Plug and fitting sizes and torques....39

Introduction

Overview

This manual includes information for the installation, maintenance, and minor repair of the Series 45 frame E open circuit axial piston pumps. The manual includes a description of the units and their individual components, troubleshooting information, and minor repair procedures. Performing installation, maintenance, and minor repair of Series 45 E frame axial piston pumps according to the procedures in this manual will not affect your warranty.

Performing minor repairs requires the unit to be removed from the vehicle/machine. Thoroughly clean the unit before beginning maintenance, or repair activities. Since dirt and contamination are the greatest enemies of any type of hydraulic equipment, follow cleanliness requirements strictly. This is especially important when changing the system filter and when removing hoses or plumbing.

A worldwide network of Danfoss **A**uthorized **S**ervice **C**enters (ASCs) is available for major repairs. Major repairs require the removal of the unit's endcap, which voids the warranty unless done by an ASC. Danfoss ASCs are trained by the factory and certified on a regular basis. You can locate your nearest ASC using the distributor locator at **www.powersolutions.danfoss.com**

Safety precautions

Always consider safety precautions before beginning a service procedure. Protect yourself and others from injury. Take these general precautions whenever servicing a hydraulic system.

Unintended machine movement

Warning

Unintended movement of the machine or mechanism may cause injury to the technician or bystanders. To protect against unintended movement, secure the machine or disable / disconnect the mechanism while servicing.

Flammable cleaning solvents

Warning

Some cleaning solvents are flammable. To avoid possible fire, do not use cleaning solvents in an area where a source of ignition may be present.

Fluid under pressure

Warning

Escaping hydraulic fluid under pressure can have sufficient force to penetrate your skin causing serious injury and/or infection. This fluid may also be hot enough to cause burns. Use caution when dealing with hydraulic fluid under pressure. Relieve pressure in the system before removing hoses, fittings, gauges, or components. Never use your hand or any other body part to check for leaks in a pressurized line. Seek medical attention immediately if you are cut by hydraulic fluid.

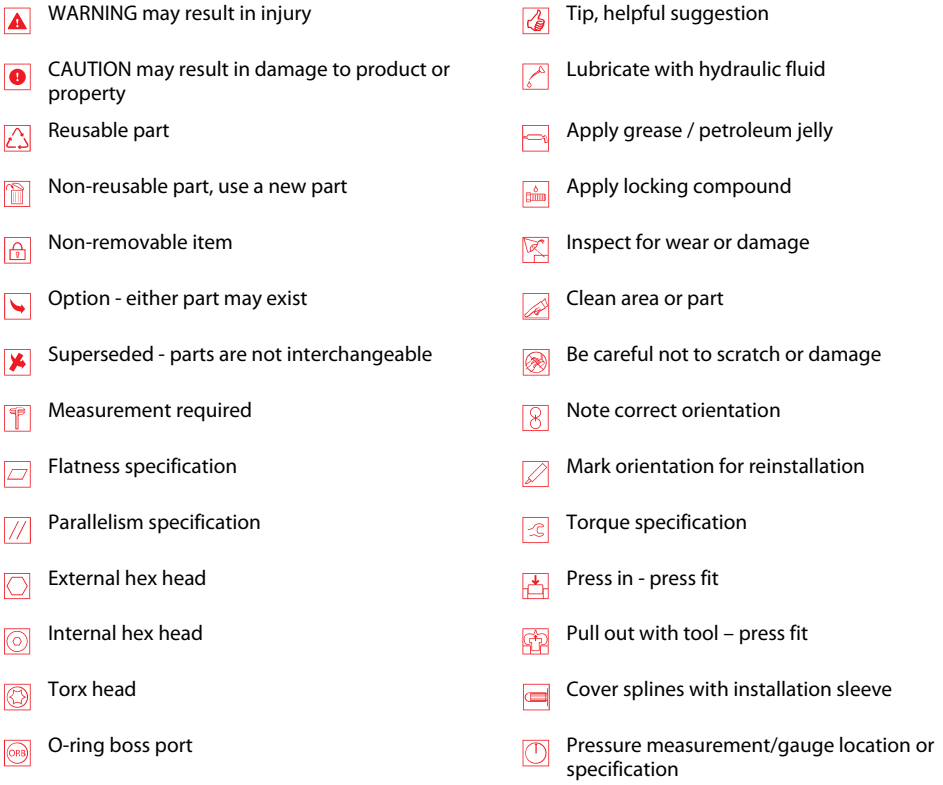
Personal safety

Warning

Protect yourself from injury. Use proper safety equipment, including safety glasses, at all times.

Introduction

Symbols used in Danfoss literature


WARNING may result in injury
CAUTION may result in damage to product or property
Reusable part
Non-reusable part, use a new part
Non-removable item
Option - either part may exist
Superseded - parts are not interchangeable
Measurement required
Flatness specification
Parallelism specification
External hex head
Internal hex head
Torx head
O-ring boss port
Tip, helpful suggestion
Lubricate with hydraulic fluid
Apply grease / petroleum jelly
Apply locking compound
Inspect for wear or damage
Clean area or part
Be careful not to scratch or damage
Note correct orientation
Mark orientation for reinstallation
Torque specification
Press in - press fit
Pull out with tool – press fit
Cover splines with installation sleeve
Pressure measurement/gauge location or specification

The symbols above appear in the illustrations and text of this manual. They are intended to communicate helpful information at the point where it is most useful to the reader. In most instances, the appearance of the symbol itself denotes its meaning. The legend above defines each symbol and explains its purpose.

Introduction

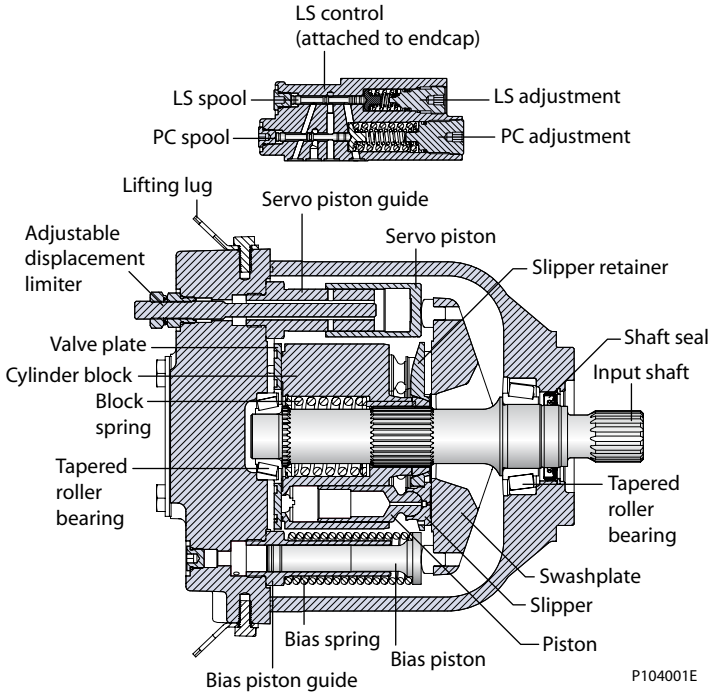
General description

Danfoss Series 45 E frame open circuit piston pumps convert input torque into hydraulic power. Rotational force is transmitted through the input shaft to the cylinder block. The input shaft is supported by tapered roller bearings at the front and rear of the pump and is splined into the cylinder block . A lip-seal at the front end of the pump prevents leakage where the shaft exits the pump housing. The spinning cylinder block contains nine reciprocating pistons. Each piston has a brass slipper connected at one end by a ball joint. The slippers are held to the swashplate by the spring retainer and block spring. The block spring also holds the cylinder block to the valve plate. The reciprocating movement of the pistons occurs as the slippers slide against the inclined swashplate during rotation. Via the valve plate, one half of the cylinder block is connected to pump inlet and the other half to pump outlet. As each piston cycles in and out of its bore, fluid is drawn from the inlet and displaced to the outlet thereby imparting power into the system circuit. A small amount of fluid is allowed to "leak" from the cylinder block / valve plate and slipper / swashplate interfaces for lubrication and cooling. Case drain ports are provided to return this fluid to the reservoir.

The volume of fluid displaced into the system circuit is controlled by the angle of the swashplate. The swashplate is forced into an inclined position (into stroke) by the bias piston and spring. The servo piston opposes the action of the bias piston and spring forcing the swashplate out of stroke when hydraulic pressure in the control circuit rises above the spring force.

The pump control, by varying the pressure at the servo piston, controls the displacement of fluid in the system circuit. Controls designed for **P**ressure **C**ompensation (PC) or **L**oad **S**ensing (LS) are available. For a detailed description of control operation, refer to *Control options* on page 13.

Pump and control sectional view



Introduction

System circuit

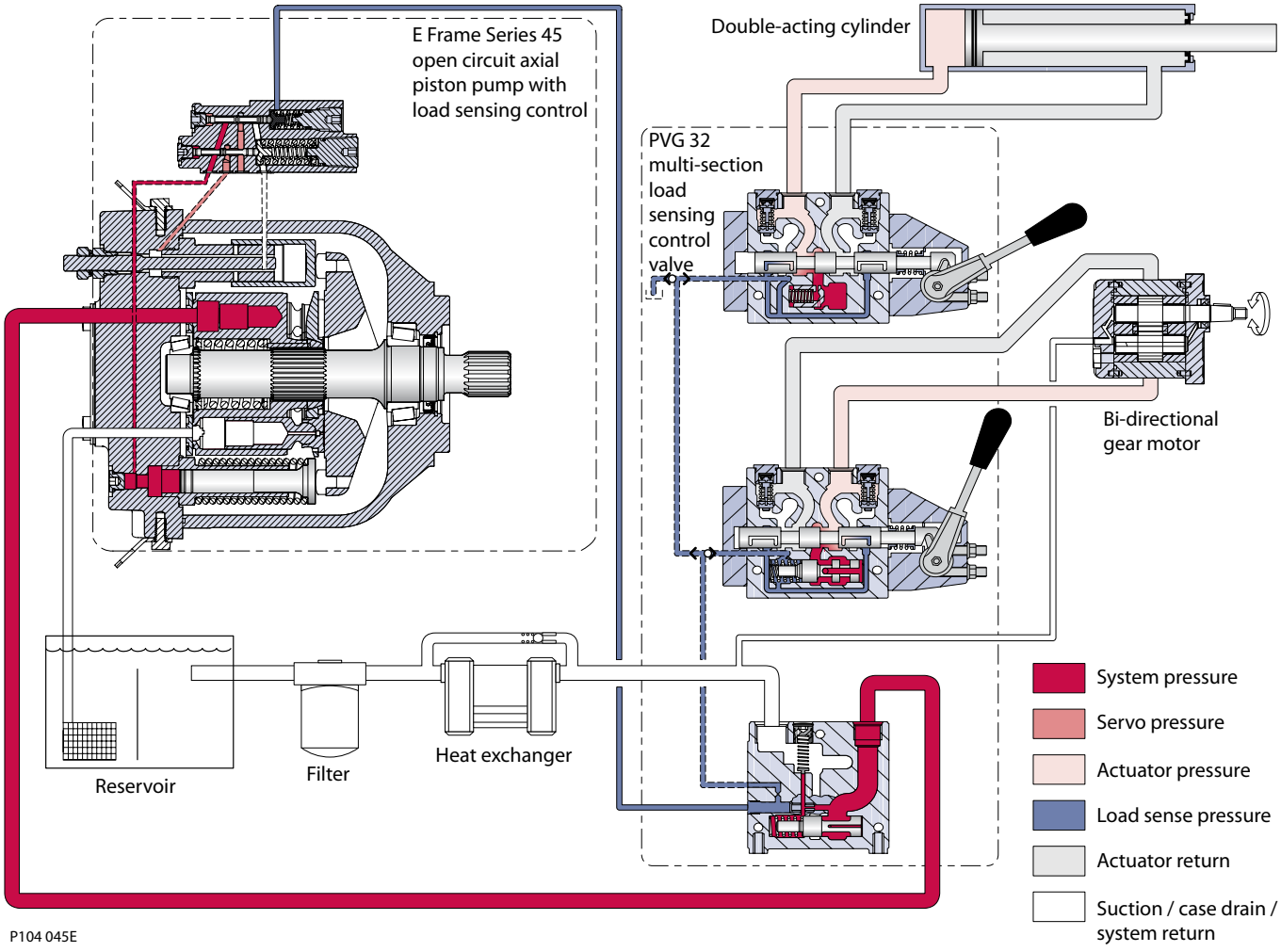
The pump receives fluid directly from the reservoir through the inlet line. A screen placed in the inlet protects the pump from large contaminants. The output of the pump is directed to a PVG-32 multi-section load sensing directional control valve which directs fluid to the actuators in the system. Fluid returning from the system is cooled by a heat exchanger and cleaned by a filter before returning to the reservoir.

The speed of the actuators in the system depends on the volume of fluid being provided by the pump. The operating pressure varies depending on actuator load, but is limited to an adjustable maximum setting by the PC section of the pump control and by a system relief valve integrated into the side module of the PVG valve.

The position of the PVG valve sets the demand for flow in the system and communicates this to the pump control by means of a hydraulic signal (load sense signal). The pump will provide as much flow to the system as it demands while limiting the maximum pressure. Therefore flow and pressure in the system are compensated to meet requirements.

Full available flow is a function of pump displacement, operating speed, and efficiency. Refer to *Series 45 Axial Piston Open Circuit Pumps Technical Information*, **520L0519** for details.

Pictorial circuit diagram



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Technical specifications

General specifications

Type of mounting

SAE-C mounting flange.

Auxiliary mounting pad options

SAE-A, SAE-B, SAE-B-B, SAE-C, SAE C-C

Control options

PC: Pressure Compensator
LS: Load Sensing (with PC)

Port options

Inlet and system ports:

- SAE flanged ports, code 61 Inlet Code 62 outlet.
- Axial (end) ports or radial (side) ports.

All other ports:

- SAE straight thread O-ring boss.

Direction of rotation

Clockwise or counterclockwise.

Installation position

Installation position is discretionary. To satisfy inlet pressure conditions, it is recommended that the pump always be located below the lowest level of hydraulic fluid in the reservoir. The housing must always be filled with hydraulic fluid.

Technical specifications

Features and options

Feature		Unit	Model		
			E100B	E130B	E147C
Maximum Displacement		cm^3 [in^3]	100 [6.10]	130 [7.93]	147 [8.97]
Flow at rated speed (theoretical)		l/min [US gal/min]	245 [64.7]	286 [75.6]	309 [81.6]
Input torque at maximum displacement (theoretical)		N•m/bar [lbf•in/1000 psi]	1.592 [972]	2.069 [1263]	2.340 [1428]
Mass moment of inertia of internal rotating components		$kg•m^2$ [$slug•ft^2$]	0.0128 [0.0094]	0.0128 [0.0094]	0.0128 [0.0094]
Weight	Axial ports	kg [lb]	51.3 [113]		
	Radial ports		54.9 [121]		
Rotation			Clockwise, Counterclockwise		
Mounting			SAE-C		
Auxiliary mounting			SAE-A, SAE-B, SAE-BB, SAE-C, SAE-CC		
System ports (type)			4-bolt split flange		

Technical specifications

Features and options (continued)

Feature	Unit	Model		
		E100B	E130B	E147C
System ports (location)		Axial, Radial		
Control types		PC, Remote PC, LS, LS with internal bleed		
Shafts	Splined	13-tooth, 14-tooth, 17-tooth		
	Straight	Ø 38.08 mm [1.5 in]		
Displacement limiters		Optional, adjustable		

Ratings

Rating		Units	Model		
			E100B	E130B	E147C
Input speed[1]	minimum	min-1 (rpm)	500	500	500
	continuous		2450	2200	2100
	maximum		2880	2600	2475
Working pressure	continuous	bar [psi]	310 [4495]	310 [4495]	260 [3770]
	maximum		400 [5800]	400 [5800]	350 [5075]
External shaft loads	External moment (Me)	N•m [lbf•in]	455 [4030]	360 [3190]	396 [3500]
	Thrust in (Tin), out (Tout)	N [lbf]	2846 [640]	1735 [390]	2113 [475]
	Thrust out (Tout)		7740 [1740]	6672 [1500]	7117 [1600]
Bearing life	at 140 bar [2030 psi]	B10 hours	77 200	32 700	21 600
	at 210 bar [3045 psi]		19 800	8400	5500
	at 260 bar [3770 psi]		9700	4116	2700
	at 310 bar [4495 psi]		5400	2300	—
Mounting flange load moments	Vibratory (continuous)	N•m [lbf•in]	1920 [17 000]		
	Shock (max)		6779 [60 000]		

(1) Input speeds are valid at 1 bar absolute [0 in Hg vac] inlet pressure. See Inlet pressure vs. speed charts in the *Series 45 Technical Information Manual* **520L0519**.

Technical specifications

Hydraulic parameters

Inlet pressure

Minimum pressure, continuous = 0.8 bar absolute [6.7 inch Hg vac] (at reduced maximum pump speed)

Minimum pressure, cold start = 0.5 bar absolute [15.1 inch Hg vac]

Pressure compensator valve setting

Setting	100 and 130 cc	147 cc
Minimum	100 bar [1450 psi]	
Maximum	310 bar [4495 psi]	260 bar [3770 psi]

Case pressure

Maximum continuous: 0.5 bar [7 psi] Above inlet
Intermittent: 2 bar [29 psi] Cold start

Hydraulic fluid

Refer to Danfoss publication *Fluids and Filtration* **BLN-9887** or **520L0463**. For information on biodegradable fluids refer to *Biodegradable Hydraulic Fluids* **520L0465**. See *Fluid and Filter Maintenance* on page 20 for recommended fluid and filter change intervals.

Temperature range [1]

Intermittent (cold start): - 40° C [- 40° F]

Continuous: 82° C [180° F]

Maximum [2]: 104° C [220° F]

(1) Hydraulic fluid viscosity must be maintained within the prescribed limits.
(2) As measured at the hottest point in the system, e.g. drain line.

Fluid viscosity

Viscosity limits

Rating		mm2/s (cSt) [SUS]
v continuous	minimum	9 [58]
	maximum	110 [500]
v intermittent	minimum	6.4 [47]
	maximum (cold start)	1000 [4700]

Filtration

Required cleanliness level: ISO 4406 Class 18/13 or better. Refer to Danfoss publications *Fluids and Filtration* **BLN-9887** or **520L0463** and *Design Guidelines for Selecting and Maintaining the Required Hydraulic Fluid Cleanliness* **520L0465**. See *Fluid and Filter Maintenance* on page 20 for recommended fluid and filter change intervals.

Features

Displacement limiter

Frame E Series 45 pumps are available with an optional adjustable maximum displacement limiter. The adjustable stop limits the pump's maximum displacement. The displacement change per turn of the displacement limiter adjustment screw is shown below.

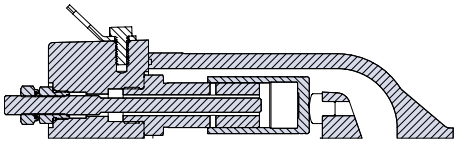
Setting range

100 cc	40 to 100 cm^3 [2.44 to 6.1 in^3]
130 cc	70 to 130 cm^3 [4.27 to 7.93 in^3]
147 cc	87 to 147 cm^3 [5.31 to 8.97 in^3]

Displacement change

100 cc	8.4 cc/rev [0.513 in^3/rev]
130 cc	
147 cc	

Displacement limiter



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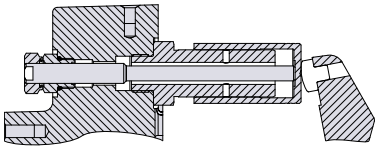
Displacement change - older models

100 cc	6.5 cc/rev [0.397 in^3/rev]
130 cc	
147 cc	

Displacement limiter - older models



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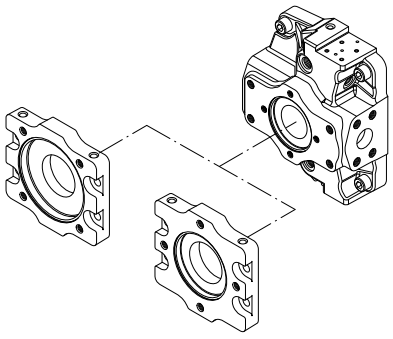
Auxiliary mounting pads

Auxiliary mounting pads are available for all radial ported Series 45 pumps. These pads are typically used for mounting auxiliary hydraulic pumps.

Since the auxiliary pad operates under case pressure, you must use an O-ring to seal the auxiliary pump mounting flange to the pad. Oil from the main pump case lubricates the drive coupling. For details refer to *Series 45 Axial Piston Open Circuit Pumps Technical Information* **520L0519**.

Features

Auxiliary pad options



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Input shafts

Series 45 E frame pumps are available with a variety of splined and straight keyed shafts. For information on shafts refer to *Series 45 Axial Piston Open Circuit Pumps Technical Information* **520L0519**.

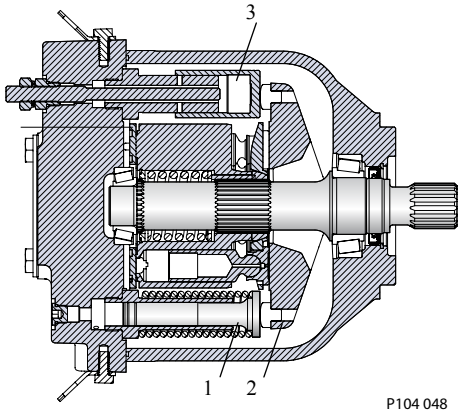
Control options

The Series 45 Frames E have three possible control options, a **L**oad **S**ensing (LS) control with **P**ressure **C**ompensator (PC), a PC only control, or an electric control.

General

The bias piston and spring (1) acts at all times to push the swashplate (2) to maximum angle causing the pump to stroke. The servo piston (3) acts against the bias piston and spring to reduce the swashplate angle causing the pump to destroke. Swashplate angle determines pump outlet flow. The pump control, depending on conditions in the system circuit, sets swashplate angle by metering system pressure to the servo piston.

Cross-section pump



P104 048

Bias spring and servo piston set swashplate position

PC control

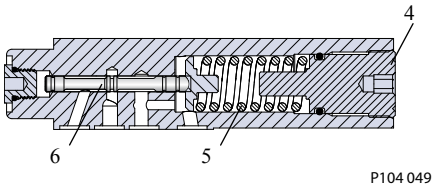
The PC control design maintains a constant pressure in the hydraulic circuit as flow varies. The PC control modulates pump flow accordingly to maintain system pressure at the PC setting as the PC adjusting plug (4) and spring (5) defines.

When system pressure, acting on the non-spring end of the PC spool (6), overcomes the force of the PC spring, the spool shifts porting system pressure to the servo piston and the swashplate angle decreases.

Features

When system pressure drops below the PC setting, the PC spring shifts the spool in the opposite direction connecting the servo piston to pump case and the swashplate angle increases. The swashplate is maintained at whatever angle is required to keep system pressure at the PC setting.

Cross-section PC control



PC spool shifts to port system pressure to servo piston

LS control

The LS control design matches pump flow with system demand. The LS control senses the flow demand of the system as a pressure drop across the External Control Valve (ECV). As the ECV opens and closes, the pressure delta across the valve changes. When opening, the delta decreases. When closing, the delta increases. The LS control then increases or decreases pump flow to the system until the pressure delta becomes equal to the LS setting as defined by the LS adjusting plug (7) and spring (8).

The LS control consists of two spool valves that connect the servo piston either to pump case or system pressure. The PC spool (6) controls the pressure-compensating function of the control as previously described. The LS spool (9) controls the load-sensing function. The PC spool has priority over the LS spool.

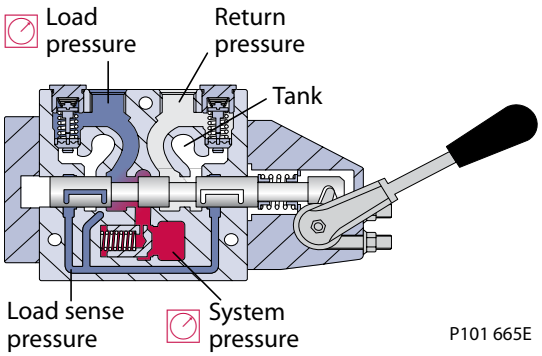
Through internal porting, system pressure (upstream of ECV) is applied to the non-spring end of the LS spool, and through hydraulic line connected at port X, LS pressure (downstream of ECV) is applied to the spring end. This arrangement allows the LS spool to act on the delta between system pressure and LS pressure. The LS spring sets the threshold of operation (LS setting).

Because the swashplate is biased to maximum angle, the pump attempts to deliver full flow to the hydraulic system. When the flow being delivered exceeds demand, the pressure delta across the ECV is great enough to overcome spring force and shift the LS spool porting system pressure to the servo piston. The pump de-strokes reducing flow until the delta across the ECV becomes equal to the LS setting. When flow being delivered is less than demand, the delta across the ECV drops below the LS setting and the LS spring shifts the spool connecting the servo piston to pump case. The pump strokes increasing flow until the delta across the ECV becomes equal to the LS setting.

When the external control valve is placed in neutral, it connects the LS signal line to drain. With no LS pressure acting on the non-spring end of the LS spool, the pump adjusts stroke to whatever position necessary to maintain system pressure at the LS setting. The pump is now in standby mode.

Because of the series arrangement of the LS and PC spools, the PC spool will override the LS spool. If at any time system pressure reaches the PC setting, the PC spool will shift blocking the passage that connects the LS spool with the servo piston and porting system pressure to the servo piston causing the pump to destroke.

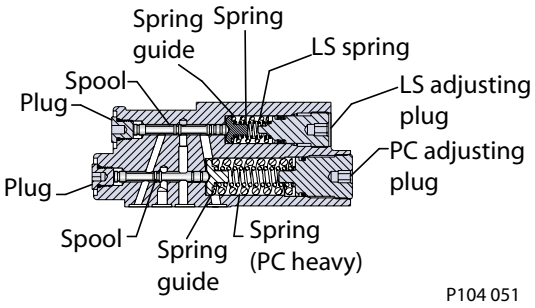
Typical load-sensing control valve



Features

Pressure drop across external control valve defines system demand

Cross-section LS control



LS spool shifts to port system pressure to servo piston

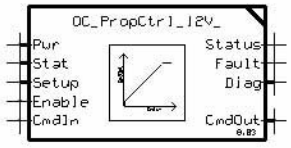
Electric Proportional Controls

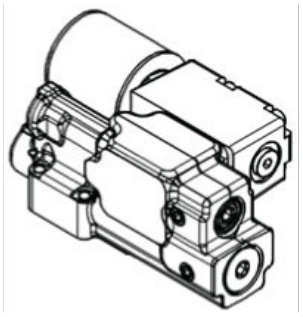
Plus+1™ Compliance

All Series 45 Electric controls have met and passed the Danfoss PLUS+1® compliance standard testing, and as such, this Series 45 control is PLUS+1® compliant. PLUS+1® compliance blocks are available on the Danfoss website, within the PLUS+1 Guide section.

Electric Proportional Control Principle

The Electric Proportional Control consists of a proportional solenoid integrated into a Remote Pressure Compensated control. This control allows the pump to be operated at any pressure limit between the Load Sense and Pressure Compensation settings by varying the current sent to the solenoid.



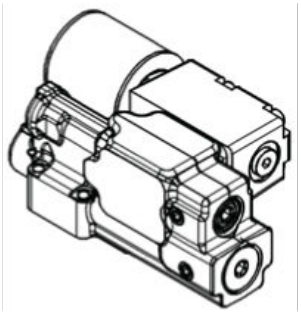


Electric On/Off Controls

PLUS+1™ Compliance

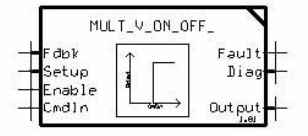
All Series 45 Electric controls have met and passed the Danfoss PLUS+1® compliance standard testing, and as such, this Series 45 control is PLUS+1® compliant. PLUS+1® compliance blocks are available on the Danfoss website, within the PLUS+1 Guide section.

Features



Electric On/Off Control Principle

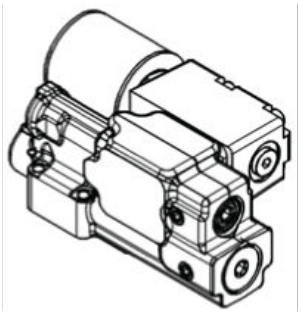
The Electric On-Off Control consists of an On/Off solenoid integrated into a Remote Pressure Compensated control. This control allows the pump to be operated at either the Load Sense pressure setting when “On”, or the Pressure Compensation pressure setting when “Off”.



Electronic Torque Limiting Controls (ETL)

PLUS+1® Compliance

All Series 45 Electric controls have met and passed the Danfoss PLUS+1® compliance standard testing, and as such, this Series 45 control is PLUS+1® compliant. PLUS+1® compliance blocks are available on the Danfoss website, within the PLUS+1 Guide section.

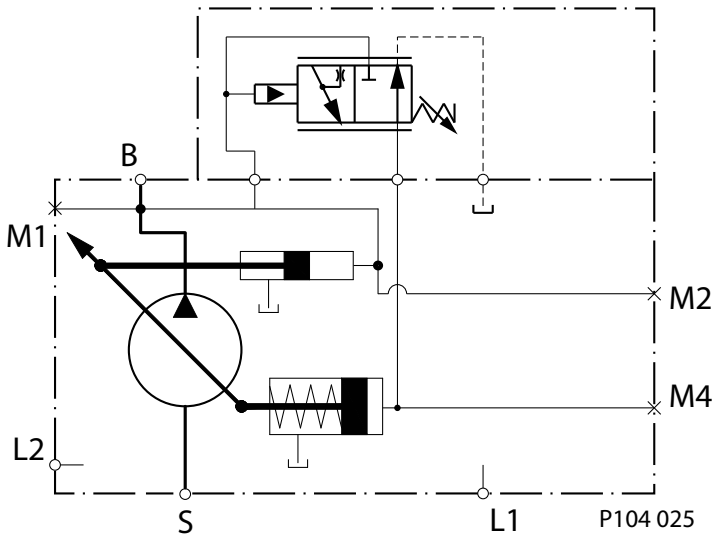


Electric Torque Limiting Control Principle

The Electronic Torque Limiting control consists of a normally closed proportional relief valve (PRV) integrated into a Pressure Compensated/Load Sensing control. This control operates as a PC/LS control, with the additional ability to limit load sense pressure using the integrated PRV by varying the current to

Features

the solenoid. When combined with an angle sensor, this control allows for a PC/LS control with electronic torque limiting.



Pump torque consumption is a function of pump outlet pressure, pump displacement, and pump mechanical efficiency. When pump mechanical efficiency is considered constant, the pump torque can be limited when pump displacement is known and pump pressure is controlled. As pump displacement increases, the pump outlet pressure can be limited using the PRV to result in a constant torque limit. Pump outlet pressure is equal to the load sense pressure, which is limited with the PRV, plus the margin pressure setting of the pump.

$$Torque = \frac{Pump\ Outlet\ Pressure\ (bar) * Pump\ Displacement\ (\frac{cc}{rev})}{62.8 * Pump\ Mechanical\ Efficiency\ (\%)}$$

Pressure measurement

Required tools

The service procedures described in this manual can be performed using common mechanic's hand tools. Special tools, if required are shown. Calibrate pressure gauges frequently to ensure accuracy. Use snubbers to protect gauges.

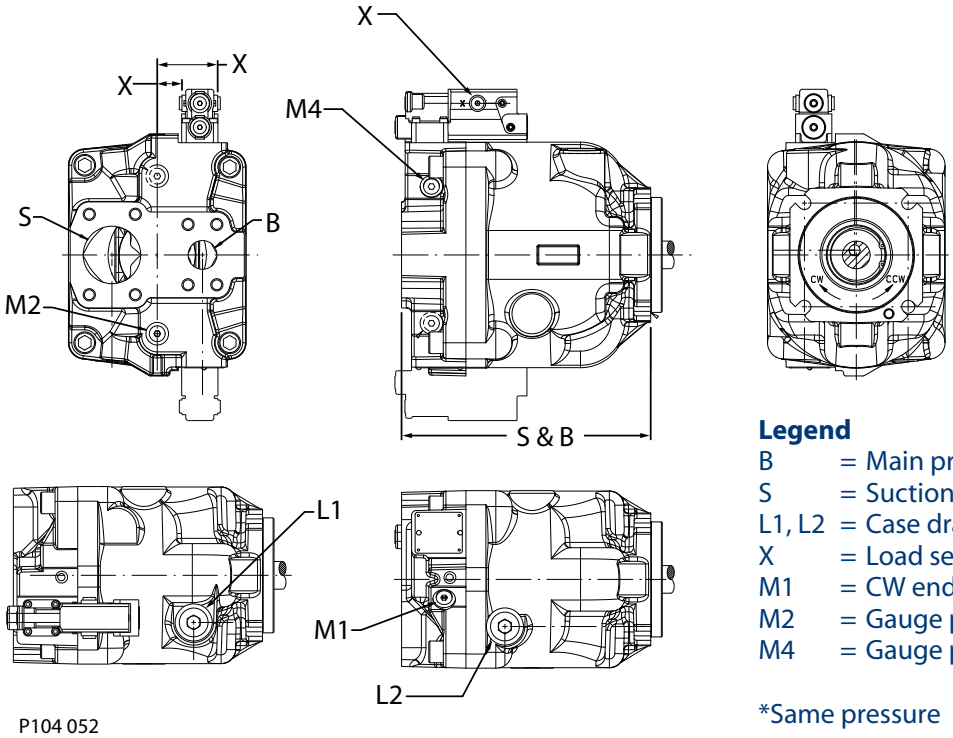
Port locations and gauge installation

The illustration below shows gauge port locations. Recommended pressure gauges and fittings are in the table.

Gauge and port information

Port	Purpose	Range of gauge	Fitting
M1, M2	System pressure	0-300 bar [0-5000 psi]	9/16 - 18 O-ring fitting
M4	Servo pressure	0-300 bar [0-5000 psi]	9/16 - 18 O-ring fitting
L1, L2	Case drain	0-300 bar [0-5000 psi]	1-1/16 - 12 O-ring fitting
X1	LS signal	0-300 bar [0-5000 psi]	7/16 - 20 O-ring fitting (tee into LS signal line)

Gauge port locations



P104 052

Legend

B = Main pressure line
S = Suction line
L1, L2 = Case drain lines
X = Load sensing pressure port
M1 = CW endcap system pressure gauge*
M2 = Gauge port for port B*
M4 = Gauge port — servo pressure

*Same pressure

Initial Start-Up Procedures

General

Follow this procedure when starting-up a new Series 45 installation or when restarting an installation in which the pump has been removed.

Warning

Unintended movement of the machine or mechanism may cause injury to the technician or bystanders. To protect against unintended movement, secure the machine or disable/disconnect the mechanism while servicing.

Prior to installing the pump, inspect for damage incurred during shipping. Make certain all system components (reservoir, hoses, valves, fittings, heat exchanger, etc.) are clean prior to filling with fluid.

Start-up procedure

1. Connect the pump to the prime mover. Ensure that pump shaft is properly aligned with the shaft of the prime mover.

   Caution

   Incorrect shaft alignment may result in damage to drive shaft, bearings, or seal which can cause external oil leakage.
2. Fill the reservoir with recommended hydraulic fluid. Always filter fluid through a 10 micron filter pouring into the reservoir. Never reuse hydraulic fluid.
3. Fill the main pump housing with clean hydraulic fluid. Pour filtered oil directly into the upper most case drain port.
4. Fill the inlet line leading from the pump to the reservoir. Check the inlet line for properly tightened fittings and be certain it is free of restrictions and air leaks.
5. To ensure the pump stays filled with oil, install the case drain line in the upper most case drain port.
6. Install a gauge at the system pressure gauge port to monitor system pressure during start up.

   Follow recommendations in the vehicle/machine operator's manual for prime mover start up procedures.
7. While watching the pressure gauge installed at the system pressure gauge port, jog the prime mover or run at the lowest possible speed until system pressure builds to normal levels (minimum 11 bar [160 psi]). Once system pressure is established, increase to full operating speed. If system pressure is not maintained, shut down the prime mover, determine cause, and take corrective action. Refer to the *Troubleshooting* chapter.
8. Operate the hydraulic system for at least fifteen minutes under light load conditions.
9. Check and adjust control settings as necessary after installation. Refer to the *Adjustments* chapter.
10. Shut down the prime mover and remove the pressure gauge. Replace the plug at port the system pressure gauge port.
11. Check the fluid level in the reservoir; add clean filtered fluid if necessary.

The pump is now ready for operation.

Fluid and Filter Maintenance

Recommendations

To ensure optimum life of Series 45 products, perform regular maintenance of the fluid and filter. Contaminated fluid is the main cause of unit failure. Take care to maintain fluid cleanliness when servicing.

Check the reservoir daily for proper fluid level, the presence of water, and rancid fluid odor. Water in the fluid may be noted by a cloudy or milky appearance or free water in the bottom of the reservoir. Rancid odor indicates the fluid has been exposed to excessive heat. Change the fluid immediately if these conditions occur. Correct the problem immediately.

Change the fluid and filter per the vehicle/machine manufacturer's recommendations or at these intervals:

Change the fluid more frequently if it becomes contaminated with foreign matter (dirt, water, grease, etc.) or if the fluid is subjected to temperature levels greater that the recommended maximum.

Dispose of used hydraulic fluid properly. Never reuse hydraulic fluid.

Change filters whenever the fluid is changed or when the filter indicator shows that it is necessary to change the filter. Replace all fluid lost during filter change.

Fluid and filter change interval

Reservoir type	Maximum change interval
Sealed	2000 hours
Breather	500 hours

Troubleshooting

Excessive noise and/or vibration

Item	Description	Action
Check fluid level in reservoir.	Insufficient hydraulic fluid causes cavitation.	Fill the reservoir to proper level.
Check for air in system.	Air in system causes noisy, erratic control.	Purge air and tighten fittings. Check inlet for leaks.
Check pump inlet pressure/vacuum.	Improper inlet conditions cause erratic behavior and low output flow.	Correct pump inlet pressure / vacuum conditions. Refer to the *Hydraulic Parameters* topic.
Inspect shaft couplings.	A loose or incorrect shaft coupling causes excessive noise and/or vibration.	Repair or replace coupling and ensure that correct coupling is used.
Check shaft alignment.	Misaligned shafts create excessive noise and/or vibration.	Correct shaft misalignment.
Hydraulic fluid viscosity above acceptable limits.	Hydraulic fluid viscosity above acceptable limits or low fluid temperature will not allow the pump to fill or control to operate properly.	Allow system to warm up before operating, or use fluid with the appropriate viscosity grade for expected operating temperatures. See *Hydraulic Fluids and Lubricants Technical Information Manual*, **520L0463**.

Actuator response is sluggish

Item	Description	Action
Check external system relief valve setting.	Low external relief valve setting slows down system.	Adjust external relief valve setting following manufacturer's recommendations. External relief setting must be above PC setting to operate properly.
Check PC and LS control setting.	Low PC setting prevents the pump from achieving full stroke. Low LS setting limits output flow.	Adjust PC and LS setting. Refer to the *Adjustments* chapter.
Check LS control signal pressures.	Incorrect LS signal will not allow pump to operate correctly.	Inspect system to ensure that proper LS signal transmit to pump.
Internal system leaks.	Worn internal parts don't allow the pump to operate properly.	Refer to Authorized Service Center for required repair.
Hydraulic fluid viscosity above acceptable limits.	Hydraulic fluid viscosity above acceptable limits or low fluid temperature will not allow the pump to fill or control to operate properly.	Allow system to warm up before operation or sue fluid with the appropriate viscosity grade for expected operating temperatures. See *Hydraulic Fluids and Lubricants Technical Information Manual*, **520L0463**.
Check external system valving.	Malfunctioning valving may not allow system to respond properly.	Repair or replace system valving as required.
Check pump case pressure.	High case pressure causes the system to be sluggish.	Correct case drain line restrictions.
Check pump inlet pressure/vacuum.	High inlet vacuum causes low output flow.	Correct inlet pressure conditions.

System operating hot

Item	Description	Action
Check fluid level in reservoir.	Insufficient volume of hydraulic fluid will not meet cooling demands of system.	Fill reservoir to proper level. Verify proper size of reservoir.
Inspect heat exchanger. Check air flow and input air temperature for the heat exchanger.	Insufficient air flow, high input air temperature, or undersized heat exchanges will not meet cooling demands of the system.	Clean, repair, or replace heat exchanger as required. Verify proper size of heat exchanger.

Troubleshooting

Item	Description	Action
Check external system relief valve setting.	Fluid passing through relief valve adds heat to system.	Adjust external system relief valve setting following manufacturer's recommendations. External relief valve setting must be above PC setting for proper operation.
Check pump inlet pressure/vacuum.	High inlet vacuum adds heat to system.	Correct inlet pressure/vacuum conditions.

Low pump output flow

Item	Description	Action
Check fluid level in reservoir.	Insufficient hydraulic fluid will limit output flow and cause internal damage to pump.	Fill the reservoir to proper level.
Hydraulic fluid viscosity above acceptable limits.	Fluid viscosity above acceptable limits or low fluid temperature will not allow the pump to fill or control to operate properly.	Allow system to warm up before operating, or use fluid with the appropriate viscosity grade for expected operating temperatures. See *Hydraulic Fluids and Lubricants Technical Information Manual*, **520L0463**.
Check external system relief valve setting.	Eternal relief valve set below PC setting causes low output flow.	Adjust external relief valve following manufacturer's recommendation. External relief valve setting must be above PC setting to operate properly.
Check PC and LS control setting.	Low PC setting prevents the pump from achieving full stroke.	Adjust PC and LS setting. Refer to the *Adjustments* chapter.
Check pump inlet pressure/vacuum.	High inlet vacuum causes low output flow.	Correct inlet pressure conditions.
Check input speed.	Low input speeds decrease flow.	Adjust input speed.
Check pump rotation.	Incorrect rotational configuration causes low flow.	Use pump with appropriate rotational configuration.

Pressure or flow instability

Item	Description	Action
Check for air in system.	Air in system causes erratic operation.	Activate PC allowing system to bleed air. Check inlet line for leaks and eliminate source of air ingression.
Check control spools.	Sticking control spools cause erratic operation.	Inspect spools for free movement in bore. Clean or replace.
Check LS setting.	Low LS setting may cause instability.	Adjust LS setting to proper level. See the *Adjustments* chapter.
Check LS signal line.	Blocked LS signal line interferes with proper LS operation.	Remove blockage.
Check external relief valve and PC setting.	Insufficient pressure differential between PC setting and external relief valve.	Adjust external relief valve or PC control settings to appropriate level. Relief valve setting must be above PC setting to operate properly.
Check external relief valve.	Chattering external relief valve may cause unstable feedback to pump control.	Adjust or replace relief valve.

Troubleshooting

System pressure not reaching PC setting

Item	Description	Action
Check PC control setting.	System pressure will not rise above PC setting.	Adjust PC to appropriate setting. Refer to the *Adjustments* chapter.
Check external relief valve.	External relief valve setting below PC setting presents pressure compensation.	Adjust external relief valve according to manufacturer's recommendations. External relief valve must be set above PC setting to operate properly.
Inspect PC control spring.	Broken, damaged, or missing spring will cause erratic operation.	Replace the spring as required.
Inspect PC spool for wear.	Wear of PC spool causes internal leakage in the control.	Replace the spool as required.
Inspect PC spool for proper orientation.	Improper orientation results in poor operation.	Correct orientation of spool.
Check PC control for contamination.	Contamination may interfere with movement of the PC spool.	Clean PC control components, take appropriate action to eliminate contamination.

High inlet vacuum

Caution

High inlet vacuum causes cavitation which can damage internal pump components.

Item	Description	Action
Check fluid temperature.	Low temperature increases viscosity. High fluid viscosity causes high inlet vacuum.	Allow system to warm up before operating.
Inspect inlet screen.	Blocked or restricted inlet screen causes high inlet vacuum.	Clean screen/remove blockage.
Check inlet piping.	Too many fittings, bends, or long piping causes high inlet vacuum.	Eliminate fittings to make path more direct.
Hydraulic fluid viscosity above acceptable limits.	High fluid viscosity causes high inlet vacuum.	Select fluid with appropriate viscosity for expected operating temperature. See *Hydraulic Fluids and Lubricants Technical Information Manual*, **520L0463**.

Adjustments

PC control

PC setting is indicated in the pump model code. Refer to the *Series 45 Open Circuit Axial Piston Pumps Technical Information Manual*, **520L0519**, for more information.

Before performing adjustments, read *Pressure measurement*.

1. Install a pressure gauge in port M1 or M2 to measure system pressure. Install a pressure gauge in case drain port L1 or L2 to measure case pressure.

Warning

Escaping hydraulic fluid under pressure can have sufficient force to penetrate your skin causing serious injury and/or infection. Relieve pressure in the system before removing hoses, fittings, gauges, or components.

Unintended movement of the machine or mechanism may cause injury to the technician or bystanders. To protect against unintended movement, secure the machine or disable / disconnect the mechanism while servicing.

Caution

Contamination can damage internal components and void the manufacturer's warranty. Take precautions to ensure system cleanliness when removing and reinstalling system lines.

2. Start the prime mover and allow fluid to reach normal operating temperature. Operate a hydraulic function to its full extension, loading the pump at maximum pressure and zero flow.
3. Loosen the PC set screw and turn the PC adjusting plug until the desired setting is indicated on the pressure gauge at port M1 or M2 (1). Clockwise rotation increases pressure, counterclockwise rotation decreases; approximate gain 42 bar [610 psi] per turn.

If the pressure does not increase, an external system relief valve may require adjustment. External system relief valve must be set above the PC setting for proper operation.

(1) P C setting is referenced to case pressure. Subtract case pressure from system pressure to compute the actual setting.

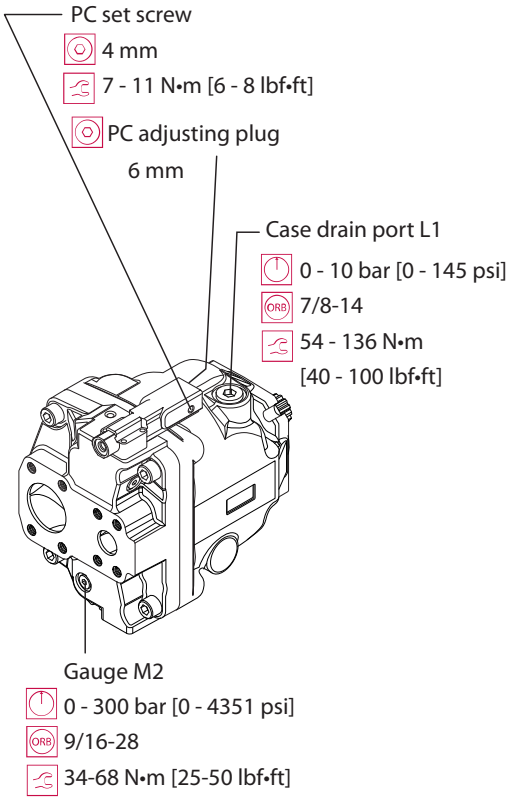
4. While holding the position of the PC adjusting plug, torque the PC set screw to 7.5 - 10.8 N•m [5.5 - 8 lbf•ft].
5. Stop the prime mover, remove the pressure gauges, and return the system to its normal operating configuration.

Pressure change

Control option	PC adjustment	LS adjustment
LS, LD, LB, LE, PC, RP	42 bar/rev [609 PSI/rev]	17.2 bar/rev [250 PSI/rev]
BB, BC, BP, BS	36 bar/rev [534 PSI/rev]	
AB, AC, AD, AJ, AS	8.5 bar/rev [123 PSI/rev]	

Adjustments

PC control adjustment



Adjustments

LS control

The LS setting is indicated in the pump model code. Refer to the *Series 45 Open Circuit Axial Piston Pumps Technical Information Manual*, **520L0519**, for more information.

Before performing adjustments, read *Pressure measurement*.

1. Install a pressure gauge in port M1 or M2 to measure system pressure. Install a pressure gauge in drain port L1 or L2 to measure case pressure. Tee-in a gauge to the LS / remote PC signal line (port X).

   Warning

   Escaping hydraulic fluid under pressure can have sufficient force to penetrate your skin causing serious injury and/or infection. Relieve pressure in the system before removing hoses, fittings, gauges, or components.

   Unintended movement of the machine or mechanism may cause injury to the technician or bystanders. To protect against unintended movement, secure the machine or disable / disconnect the mechanism while servicing.

   Caution

   Contamination can damage internal components and void the manufacturer's warranty. Take precautions to ensure system cleanliness when removing and reinstalling system lines.

2. Start the prime mover and allow fluid to reach normal operating temperature. Slowly operate a hydraulic function that will demand approximately half flow from the pump, but keep system pressure below the PC set point.
3. Loosen the LS set screw. While watching the pressure gauges, turn the LS adjusting plug until the desired pressure differential between port M1 or M2 and port X is achieved (1). Clockwise rotation increases the setting, counterclockwise rotation will decrease it; approximate gain = 17 bar [250 psi] per turn.

   (1) The LS setting is a differential pressure. Subtract pilot pressure at port X from system pressure at port M2 to compute the actual setting.
4. While holding the position of the LS adjusting plug, torque the LS set screw to 9.5 N•m [7 lbf•ft].
5. Operate a hydraulic function to its full extension loading the pump at maximum pressure and zero flow.

Adjustments

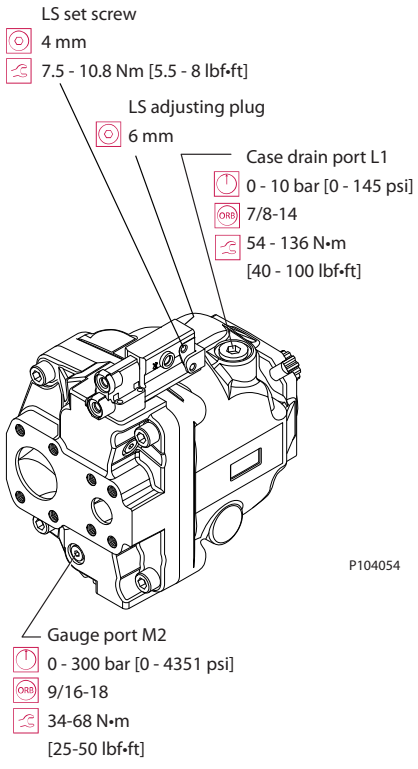
6. Loosen the PC set screw and turn the PC adjusting plug until the desired setting is indicated on the pressure gauge at port M1 or M2 (2). Clockwise rotation increases pressure, counterclockwise rotation decreases it; approximate gain = 42 bar [610 psi] per turn.

   If the pressure does not increase, an external system relief valve may require adjustment. External system relief valve must be set above the PC setting for proper operation.

   (2) PC setting is referenced to case pressure. Subtract case pressure from system pressure to compute the actual setting.

7. While holding the position of the PC adjusting plug, torque the PC set screw to 9.5 N•m [7 lbf•ft].
8. Stop the prime mover, remove the pressure gauges, and return the system to its normal operating configuration.

LS control adjustment



Adjusting plug, set screw, and gauge locations shown

Minor repair

Shaft seal replacement

The Series 45 open circuit variable pumps use a lip-type shaft seal. You can replace this seal without major disassembly of the unit. Replacing the shaft seal requires removing the pump from the machine.

Removal

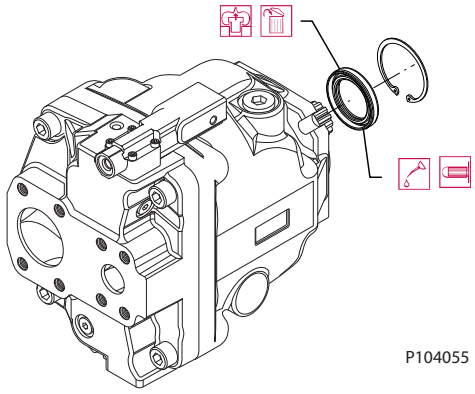
1. Using the appropriate snap-ring pliers, remove the retaining ring (K010) from the housing.
2. Remove the shaft seal (K020) from the bore in the pump housing and discard.

Caution

Don't damage the pump housing or shaft.

3. Puncture the face of the seal with a packing hook, or use a slide-hammer type puller to remove the seal.

Shaft seal and retaining ring



Installation

1. Inspect the pump housing and new seal for damage. Inspect the sealing area on the shaft for rust, wear, or contamination. Polish the sealing area on the shaft if necessary.
2. Lubricate the lip of the new shaft seal with clean hydraulic fluid. Place a protective sleeve over the shaft end to prevent damage to the seal during installation.
3. Keeping the seal perpendicular to the shaft, press the new seal into the housing just far enough to clear the retaining ring groove. Install seal with the cupped side toward the shaft bearing. Do not damage the seal during installation.

Caution

Premature bearing failure can result if the shaft seal contacts the shaft bearing.
Press the seal into the housing only far enough to clear the retaining ring groove.

4. Using the appropriate snap ring pliers, install the seal retaining ring.
5. Remove the installation sleeve.

Minor repair

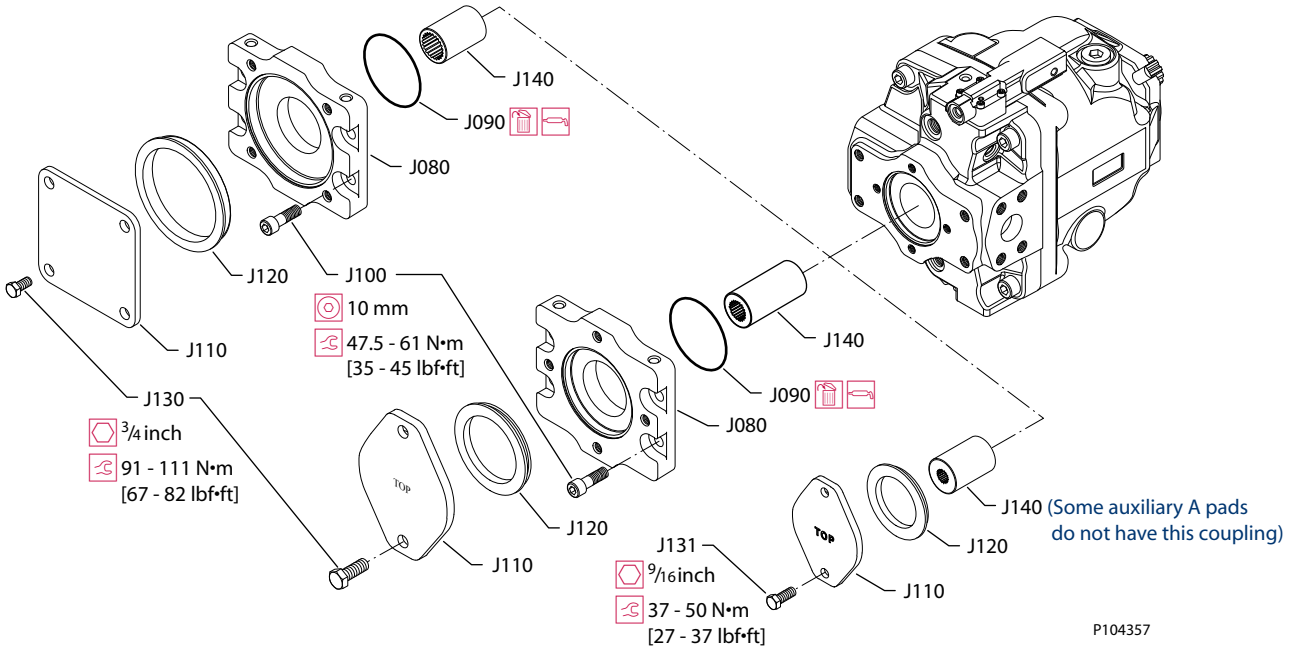
Auxiliary pads

You may install auxiliary mounting pads on pumps equipped with through-drive radial ported end caps. Follow these steps to either remove, replace, or exchange auxiliary mounting pads.

Removal

1. Remove the screws (J130), retaining the cover plate (J110) or auxiliary pump (not shown). Remove the shipping cover or auxiliary pump and its seal (J120).
2. Remove the drive coupling (J140) if present.
3. Remove the 4 screws (J100) retaining the pad adapter (J080) to the endcap. Discard the pad adapter O-ring (J090) if present.

Auxiliary mounting pads



Installation

1. Lubricate new O-ring (J090) with petroleum jelly. Install the pad adapter to the endcap.
2. Install the 4 screws (J100) and torque to 47.5 - 61 N•m [35 - 45 lbf•ft].
3. Install the drive coupling (J140) if present.
4. Install shipping cover with seal (J120) or auxiliary pump with O-ring (customer supplied).

Caution

Shipping cover is intended only to retain coupling during shipment and storage. Do not operate pump with coupling and shipping cover installed.

5. Install the screws (J130) and torque to 94 - 115 N•m [67 - 82 lbf•ft]. If you have an auxiliary A pad, install the screws (J131) and torque to 37 - 50 N•m [27 - 37 lbf•ft].

Minor repair

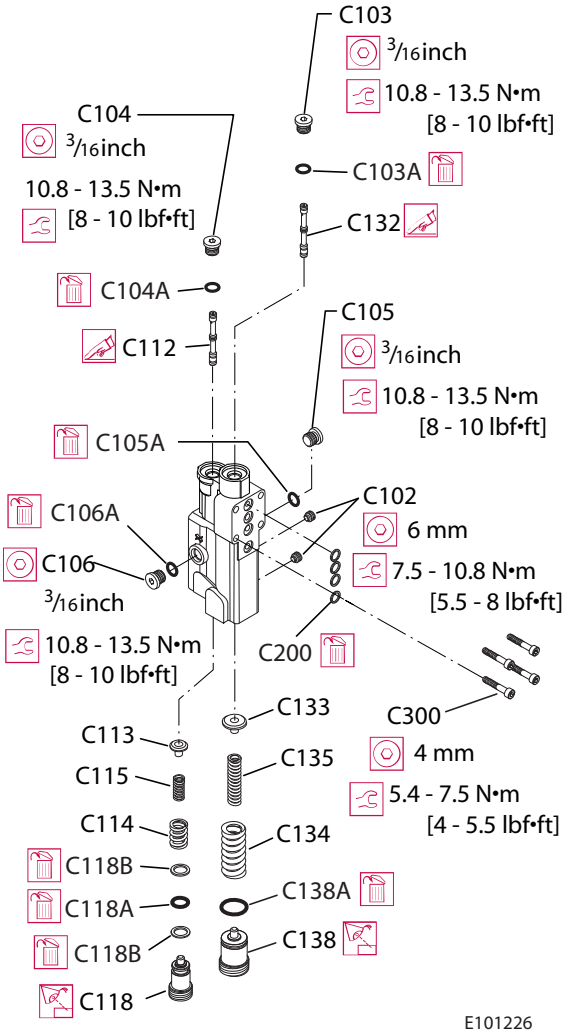
LS and PC Controls

Disassembly

1. Remove the 4 screws (C300) holding the control housing onto the end cap.
2. Remove the control and discard the 4 interface O-rings (C200).
3. Remove the PC set screw (C102), PC adjusting plug (C138), O-ring (C138A), springs (C134, C135), and seat (C133). Discard the O-ring.
4. Remove the plug (C103), O-ring (C103A), and PC spool (C132) from the control housing. Discard the O-ring. Note orientation of the spool for reassembly.

   For PC only controls, skip steps 5 through 7
5. Remove the plug (C105) and O-ring (C105A), or the plug (C106) and O-ring (C106A). Discard the O-ring (C105A or C106A).
6. Remove the LS set screw (C102), LS adjusting plug (C118), O-ring (C118A), back-up rings (C118B), springs (C114, C115), and seat (C113). Discard the C118A O-ring.
7. Remove the C104 plug, C104A O-ring, and C112 LS spool from the control housing; discard the O-ring. Note orientation of the spool for reassembly.

Control assembly



LS control shown; parts C104 through C106 and C112 through C118 are not used on PC control

Minor repair

Inspection

1. Inspect the adjusting plugs for wear at the tips and where they contact the springs; replace as necessary.
2. Inspect the springs and spring guides for wear or damage; replace as necessary.
3. Carefully inspect the spools. Ensure the sealing lands are free of nicks and scratches. Check the ends that contact the spring guides for wear. Replace spools as necessary.
4. Inspect the control housing for damage. Check the spool bores for excessive wear.
5. Clean all parts and lubricate spools, springs, guides and new O-rings with clean hydraulic fluid.

Reassembly

1. Install the PC spool (C132), spherical end first, into the PC bore. Using a new O-ring (C103A), install the plug (C103). Torque the plug (C103) to 10.8 - 13.5 N•m [8 - 10 lbf•ft].
2. Place the two PC springs (C134, C135) onto the spring guide (C133) and install into the PC bore. Place a new O-ring (C138A) onto the PC adjusting screw and thread it into the PC bore until flush, then make another full turn. Install and torque the PC set screw (C102) to 7.5 - 10.8 N•m [5.5-8 lbf•ft].
3. Install the LS spool (C112), spherical end first, into the LS bore. Using a new O-ring (C105A or C106A), install the plug (C105 or C106). Torque the plug (C105 or C106) to 10.8 - 13.5 N•m [8 - 10 lbf•ft].

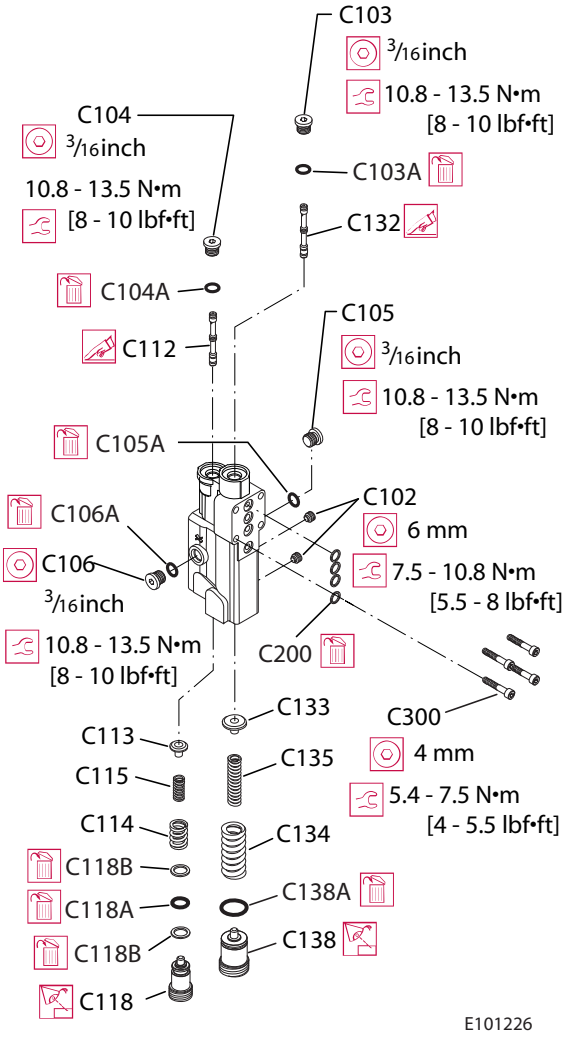
   For PC only controls, skip steps 15 through 17.

4. Using a new O-ring (C104A), install the plug (C104). Torque the plug to 10.8 - 13.5 N•m [8 - 10 lbf•ft].
5. Place the two LS springs (C134, C135) onto the spring guide (C113) and install into the LS bore. Place a new O-ring (C118A) and back-up rings (C118B) onto the LS adjusting screw and thread it into the LS bore until flush, then make another full turn. Install and torque the LS set screw (C102) to 7.5 - 10.8 N•m [5.5-8 lbf•ft].

Minor repair

6. Using petroleum jelly to retain them, install the 4 interface O-rings (C200) in the recesses on the control housing.
7. Install the control assembly onto the endcap using the 4 screws (C300). Torque the screws to 5.4 - 7.5 N•m [4 - 5.5 lbf•ft]. Torque screws in a criss-cross pattern and re-torque the first screw to ensure proper torque retention.
8. Check and adjust the control setting. See *Adjustments*.

Control assembly



LS control shown; parts C104 through C106 and C112 through C118 are not used on PC control

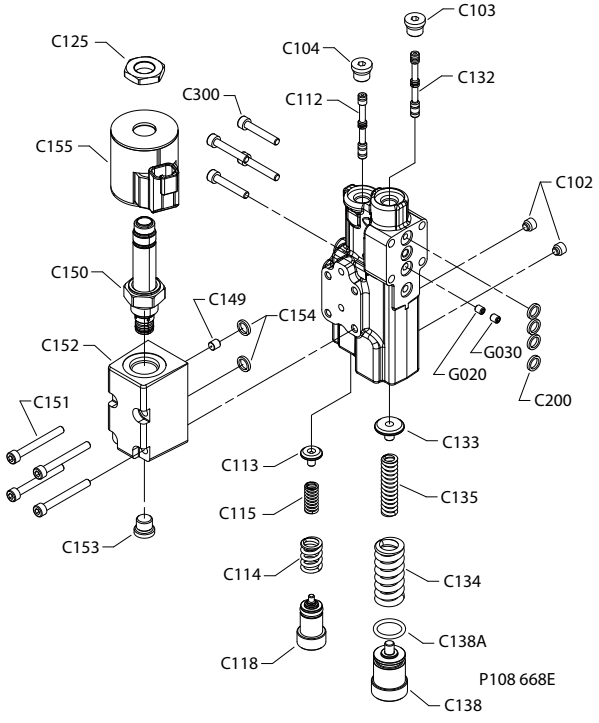
Minor repair

Electric Controls

Disassembly

1. Remove four screws (C300).
2. Remove the control and discard the four O-rings (C200).
3. Remove set screws (C102), PC adjusting plug (C138) with O-ring (C138A), springs (C134, C135), and seat (C133). Discard the O-ring if it is damaged.
4. Remove plug (C103). Remove PC spool (C132). Note orientation of the spool for reassembly.
5. Remove plug (G030), and orifice (G020).
6. Remove LS adjusting plug (C118), springs (C114, C115), and seat (C113).
7. Remove plug (C104), and spool (C112). Note the orientation of the spool for reassembly.
8. Remove four screws (C151). Remove the manifold (C152) and discard the two interface O-rings (C154).
9. For electric proportional controls only: Remove the electric control manifold drain orifice (C149).
10. Remove plug (C153). Remove the cartridge valve nut (C125), electric solenoid (C155), and cartridge valve (C150) from the electric control manifold.

Control disassembly



Inspection

1. Inspect the adjusting plugs for wear at the tips and where they contact the springs; replace as necessary.
2. Inspect the springs and spring guides for wear or damage; replace as necessary.
3. Carefully inspect the spools. Ensure the sealing lands are free of nicks and scratches. Check the ends that contact the spring guides for wear. Replace spools as necessary.
4. Inspect the control housing for damage. Check the spool bores for excessive wear.
5. Remove debris from orifices if necessary. Ensure the servo control orifice backup plug is clean, and remove debris if necessary.
6. Clean all parts and lubricate spools, springs, guides and new O-rings with clean hydraulic fluid.

Minor repair

Reassembly

1. Install the servo control orifice (G020), and torque to 2-3.4 N•m [18-30 in•lb]. Then install the orifice backup plug (G030), and torque to 2-3.4 N•m [18-30 in•lb].
2. Install the PC spool (C132), spherical end first, into the PC bore. Install plug (C103). Torque the plug to 10.8 - 13.5 N•m [8 - 10 lbf•ft].
3. Place the two PC springs (C134, C135) onto the spring guide (C133) and install into the PC bore. Place a new O-ring (C138A) onto the PC adjusting screw (C138) and thread it into the PC bore until flush, then make another full turn. Install and torque the PC set screw (C102) to 7.5 - 10.8 N•m [5.5-8 lbf•ft].
4. Install the LS spool (C112), spherical end first, into the LS bore.
5. Install plug (C104). Torque the plug to 10.8 - 13.5 N•m [8 - 10 lbf•ft].
6. Place the two LS springs (C114, C115) onto the spring guide (C113) and install into the LS bore. Thread adjusting screw (C118) into the LS bore until flush, then make another full turn. Install and torque the LS set screw (C102) to 7.5 - 10.8 N•m [5.5-8 lbf•ft].
7. Install the electric control manifold drain orifice (C149) and torque to 2-3.4 N•m [18-30 in•lb].
8. Install the cartridge valve (C150) into the electric control manifold (C152). Torque to 25.8-28.5 N•m [19-21 lbf•ft]. DO NOT OVERTORQUE the cartridge valve.
9. Install the electric solenoid (C155), and solenoid coil nut (C125). Torque to 6.8-9.5 N•m [5-7 lbf•ft].
10. Install plug (C153). Torque the plug to 10.8 - 13.5 N•m [8 - 10 lbf•ft].
11. Using petroleum jelly to retain them, install the two interface O-rings (C154) in the recesses on the electric control manifold.
12. Install the manifold assembly onto the control housing using four screws (C151). Torque the screws to 5.4 - 7.5 N•m [4 - 5.5 lbf•ft]. Torque the screws in a criss-cross pattern and re-torque the first screw to ensure proper torque retention.
13. Using petroleum jelly to retain them, install the four interface O-rings (C200) in the recesses on the control housing.
14. Install the control assembly onto the endcap using the four screws (C300). Torque the screws to 5.4 - 7.5 N•m [4 - 5.5 lbf•ft]. Torque screws in a criss-cross pattern and re-torque the first screw to ensure proper torque retention.
15. Check and adjust the control setting. See *Adjustments*.

Minor repair

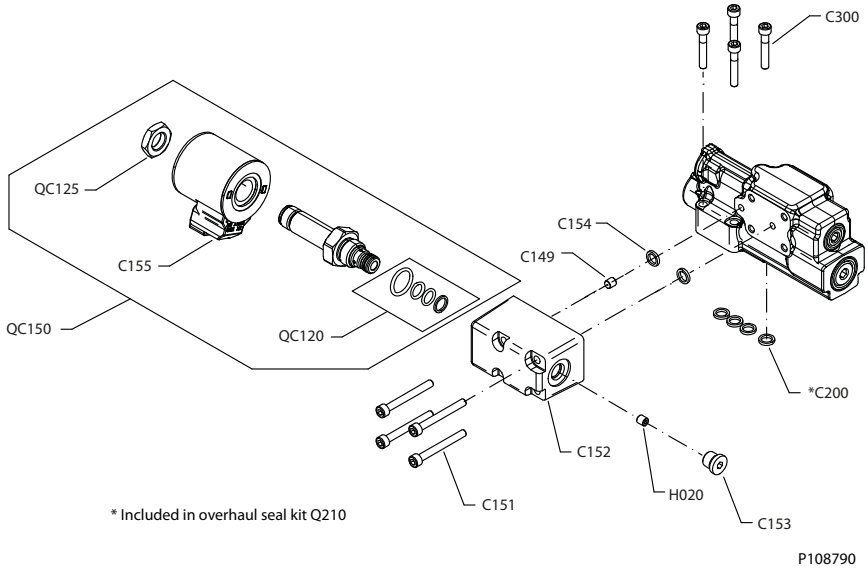
Electronic Torque Limiting Control

Repair

Disassembly, inspection and reassembly steps are the same as the steps in the previous topic (Electric Controls). This includes repair of the spools and plugs.

The solenoid (C155), nut (QC125), and O-rings (QC120) for the valve are available as separate repair parts. The valve is only available as a complete assembly (QC150).

If it is necessary to remove the orifice (H020), use a 3 mm internal hex wrench. Torque it to 2.7 Nm [24 in-lb] when it is installed in the manifold.



Item	Description	Wrench size	Torque
C149	Orifice	3 mm internal hex	2.7 Nm [24 in-lb]
C151	Screws		6.4 Nm [4.7 lbf-ft]
C152	Manifold	-	-
C153	Plug	5 mm internal hex	12 Nm [8.9 lbf-ft]
C154	O-ring	-	-
C155	Solenoid	-	-
C200	O-rings	-	-
C300	Screws		6.4 Nm [4.7 lbf-ft]
QC120	O-rings		
QC125	Nut		8.7 Nm [6.4 lbf-ft]
QC150	Valve assembly		27.7 Nm [20.4 lbf-ft]
H020	Manifold orifice	3 mm internal hex	2.7 Nm [24 in-lb}

Minor repair

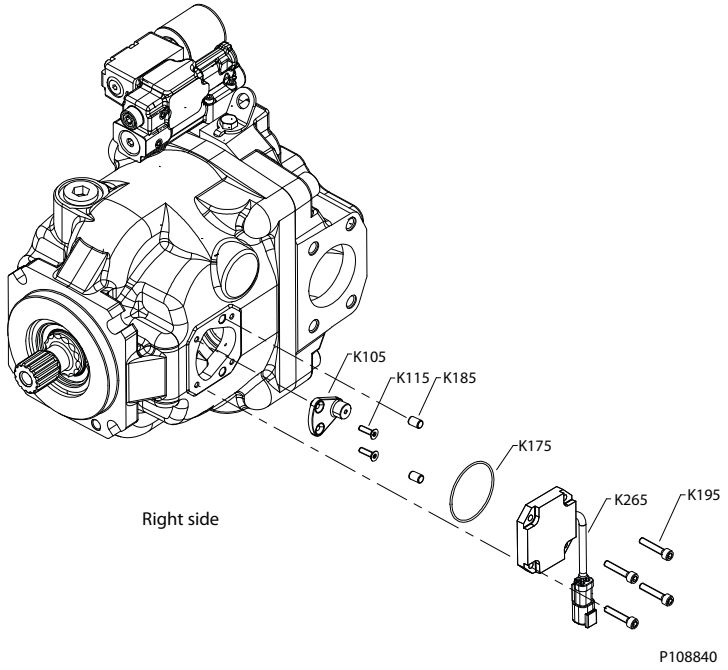
Angle Sensor

Removal

1. Remove the four sensor housing screws (K195), sensor housing (K265), and sensor housing O-ring (K175).
2. Remove two locating dowels (K185).
3. Remove two magnet carrier screws (K115) and discard. Remove magnet carrier (K105) from pump swashplate through housing.

Screws (K115) must be discarded after disassembly. Used magnet carrier screws may loosen and lead to premature failure. Ensure that new screws with locking compound are utilized.

During O-ring removal from sensor housing, be careful not to damage or scratch seal area .



Item	Description	Wrench size	Torque
K105	Magnet carrier		-
K115	Carrier screws	-	4.5 Nm [3.35 lbf ft]
K175	O-ring	-	-
K185	Locating dowels	-	-
K195	Screws		5.9 Nm [4.35 lbf ft]
K265	Housing	-	-

Inspection

Minor repair

1. Carefully examine the angle sensor housing for mechanical damages, cracks, or scratched surfaces.
2. Check the angle sensor connector for breaks, pin deformation, or contamination.
3. Check sensor wiring for heat damage, scuffing/chafing, or kinks.
4. Check sensor seal area for contamination and surface damage
5. Check magnet carrier for cracks , deformations, wearing, and for contamination with magnetic particles

Warning

A thorough inspection with the angle sensor removed is a strong indicator of pump and hydraulic system contamination and filtration quality.

Reassembly

1. Using new magnet carrier screws with locking compound (K115) install the magnet carrier (K105) to pump swashplate through the housing. Torque the screws to 4.5 Nm [3.3 lbf-ft].

Warning

Used magnet carrier screws may loosen and lead to premature failure. Ensure that new screws with locking compound are utilized.

2. Install the locating dowels (K185) into the dowel holes.
3. Lubricate new O-ring (K175) with petroleum jelly. Install the O-ring to the angle sensor housing (K265) first.
4. Install angle sensor housing (K265) with O-ring (K175) to housing with 4 screws (K195) and torque to 5.9 Nm [4.4 lbf-ft].

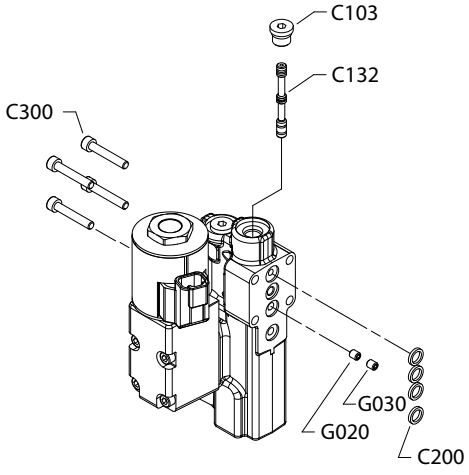
Minor repair

Servo Control Orifice

1. Remove four screws (C300).
2. Remove the control and discard the four O-rings (C200).
3. Remove PC plug (C103), and PC spool (C132) from the control housing.

   Note the orientation of the spool for reassembly.
4. Remove backup plug (G030), and orifice (G020).
5. Install the orifice (G020), and torque to 2-3.4 N•m [18-30 in•lb]. Then install the orifice backup plug (G030), and torque to 2-3.4 N•m [18-30 in•lb].
6. Install the PC spool (C132), spherical end first, into the PC bore. Install plug (C103). Torque the plug to 10.8 - 13.5 N•m [8 - 10 lbf•ft].
7. Using petroleum jelly to retain them, install the four O-rings (C200) in the recesses on the control housing.
8. Install the control assembly onto the endcap using four screws (C300). Torque the screws to 5.4 - 7.5 N•m [4 - 5.5 lbf•ft]. Torque screws in a criss-cross pattern and re-torque the first screw to ensure proper torque retention.

Control assembly



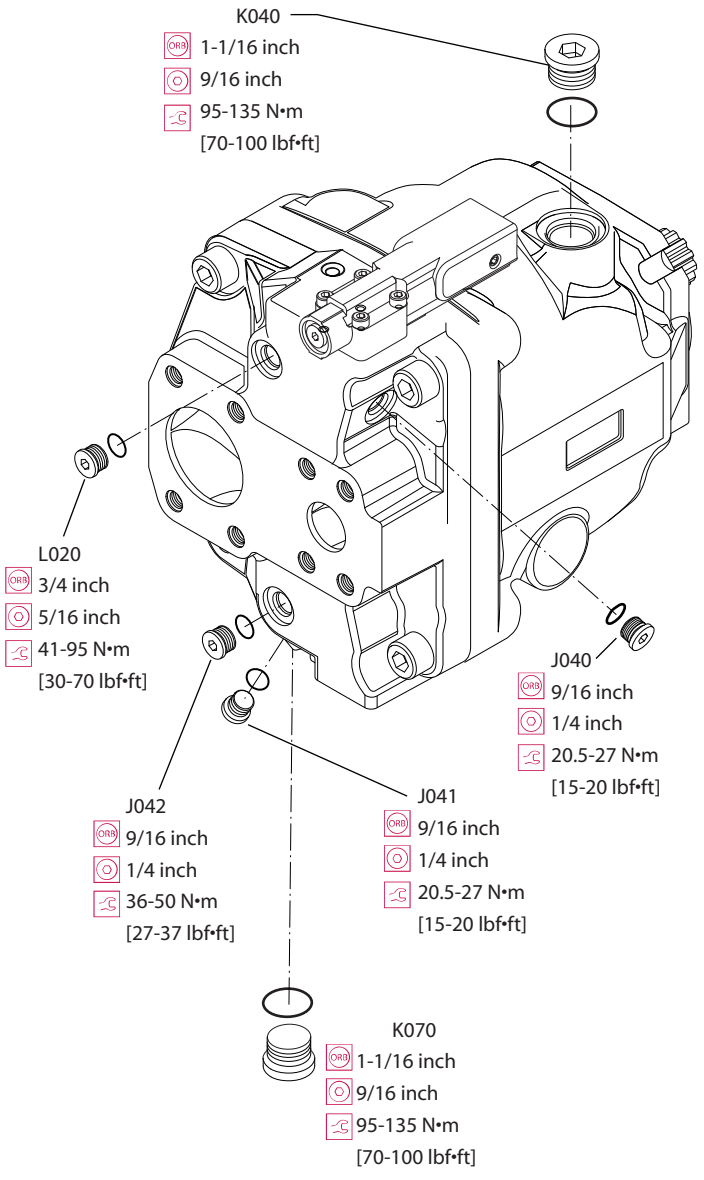
P108 669E

Minor repair

Plug and fitting sizes and torques

If any plugs or fittings are removed from the unit during service, install and torque as indicated here. This drawing is a composite. Your configuration may differ but here is the appropriate wrench size and torque:

Plug locations, sizes, and torques



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